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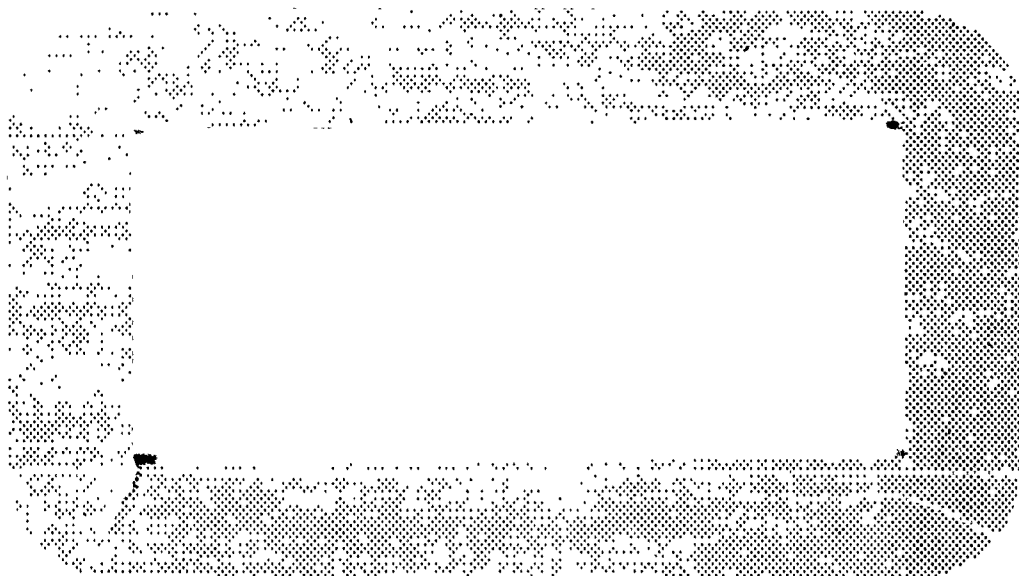
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6 A COMPUTER PROGRAM FOR FRAGMENTATION
TEST DATA REDUCTION (U) 8

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ABSTRACT

A detailed description is given of a computer program for the reduction of fragmentation data obtained from static detonation of warheads in a test arena, including input format, a listing of the FORTRAN ~~IV~~ program deck, and a sample of the output from the program.

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FOREWORD

The computer program described in this report was prepared in the Ballistic Sciences Branch of the Computer Programming Division, Computation and Analysis Laboratory, by Miss Beverly A. Cooper. The work was performed under the authority of NWL Technical Assistance Request for Project No. T-06AD by the Computation and Analysis Laboratory in support of the Warhead Supporting Research Program being conducted by the Warhead and Terminal Ballistics Laboratory.

INTRODUCTION

The U. S. Naval Weapons Laboratory is currently preparing a handbook series, "Warhead and Terminal Ballistics Handbook," in conjunction with the Warhead Supporting Research Program established in accordance with Bureau of Naval Weapons Weptask No. RMMO-42-003/210-1/F008-08-06. The objective of this handbook is to provide systematic documentation of kill mechanism technology, target vulnerability data, and warhead terminal ballistic performance data. To be included, is a section on the terminal ballistic performance characteristics of bombs, projectiles, and rocket and missile warheads of current tactical interest to the Navy. A preliminary edition of this section, published as NAVWEPS Report No. 7673, is currently being revised to include data recently acquired through an extensive warhead test program conducted at the U. S. Naval Weapons Laboratory.

A significant portion of this program was a series of arena tests of statically fired warheads to establish measurements of the fragmentation characteristics--velocity, density, mass, and spatial distribution of fragments--for each of several warheads. Typically, these tests are performed in a field arena similar to the one described in Figure 1. The arena consists of two 180-degree circular sectors. One sector is constructed from 22-gauge mild steel plate, and the other is constructed of celotex panels. The warhead to be tested is positioned on a stand at the center of the arena with its axis horizontal and intersecting the sides of the arena where the two sectors meet, with the forward end of the warhead aimed at the 0-degree position on the wall. A ricochet fence is built about the stand between the warhead and the arena to prevent fragments that strike the ground from reaching the wall panels.

High-speed motion picture cameras are placed about the steel sector to record impacts of fragments from the detonated warhead on the arena plates. A kilocycle/second timing trace is superimposed on the film in each camera during operation to allow for the determination of the time lapse from detonation to impact. Given the resulting time data and the distance from the warhead to the arena plate, an estimate of the average velocity of the fragments can be obtained. Fragments impacting on the celotex sector are recovered upon completion of the test, weighed, and categorized by mass interval to obtain estimates of the fragment number and mass distribution associated with the warhead.

A spatial distribution of the fragments is constructed by tabulating the above data for each five-degree polar zone (angular interval measured from horizontal axis of warhead).

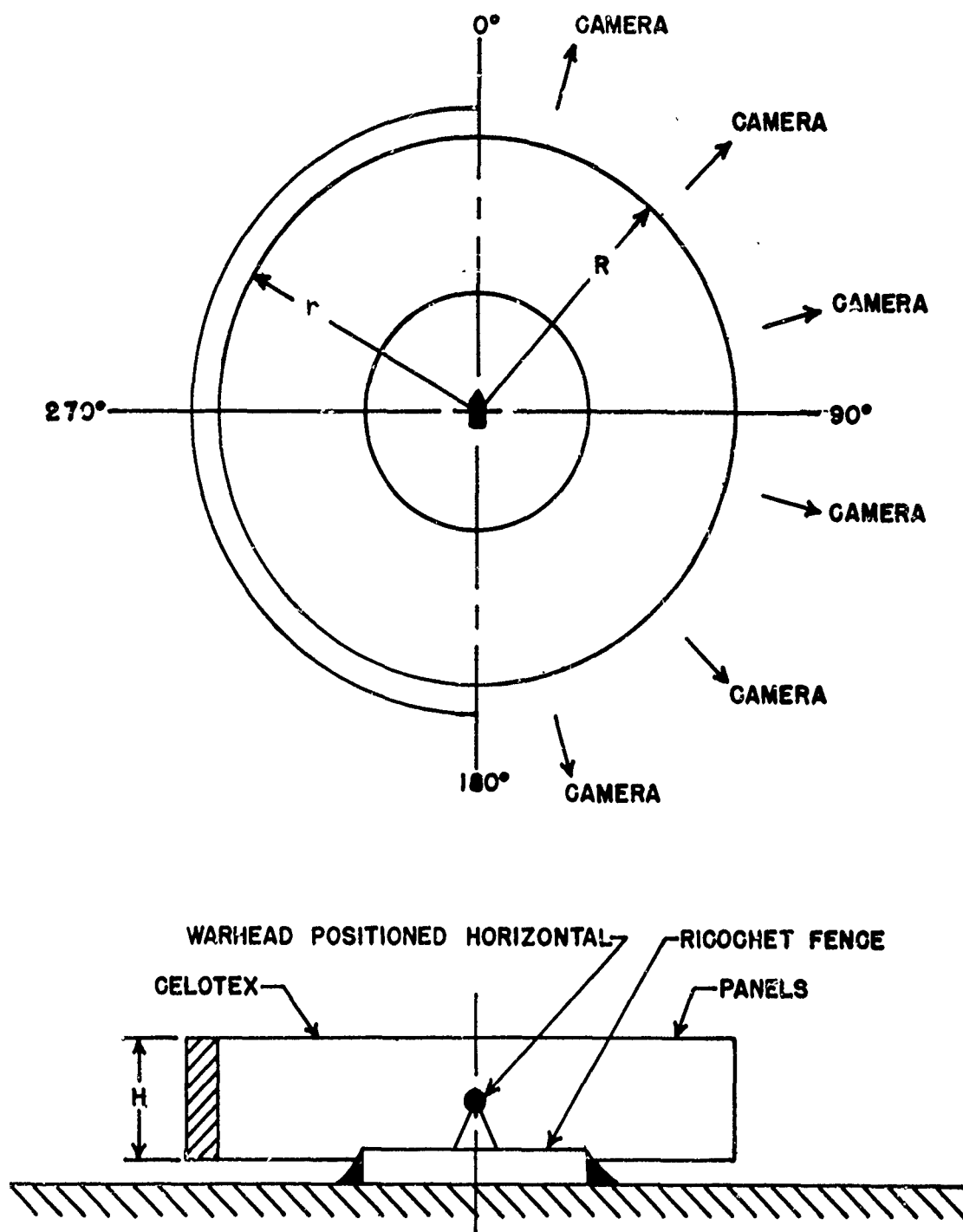


FIGURE 1. TYPICAL ARENA SET - UP

DATA REDUCTION

To facilitate and expedite reduction of the raw test data to a useful and meaningful form, a high-speed computer program was formulated and coded in FORTRAN IV for execution on an IBM 7030 computer.

The flow chart given as Figure 2 outlines the major features of the program. For each mass interval (weight group) within a polar zone, the fragment density and average mass are computed. Upon completion of these computations, initial fragment velocity, total fragment weight, and number of fragments per steradian for the polar zone are calculated. Each zone is considered in succession until the total fragment space has been spanned. These output are then tabulated as shown in Figure A-3.

a. The fragment density for each mass interval is obtained by scaling the average number of fragments recovered by the value computed from the equation:

$$\frac{A_k}{a_k} = \frac{2\pi (\cos \theta_{k+1} - \cos \theta_k)}{2 \int_{\theta_{k+1}}^{\theta_k} \sin \theta \arcsin \left(\frac{\sin x}{\sin \theta} \right) d\theta}$$

where,

$$\arctan x = \frac{H}{2r}$$

r = radius of mass arena, feet

H = height of mass arena, feet

θ_k = angular distance from horizontal axis of warhead to the lower bound of k -th polar zone

The average mass is simply the total weight of the recovered fragments divided by the number of fragments.

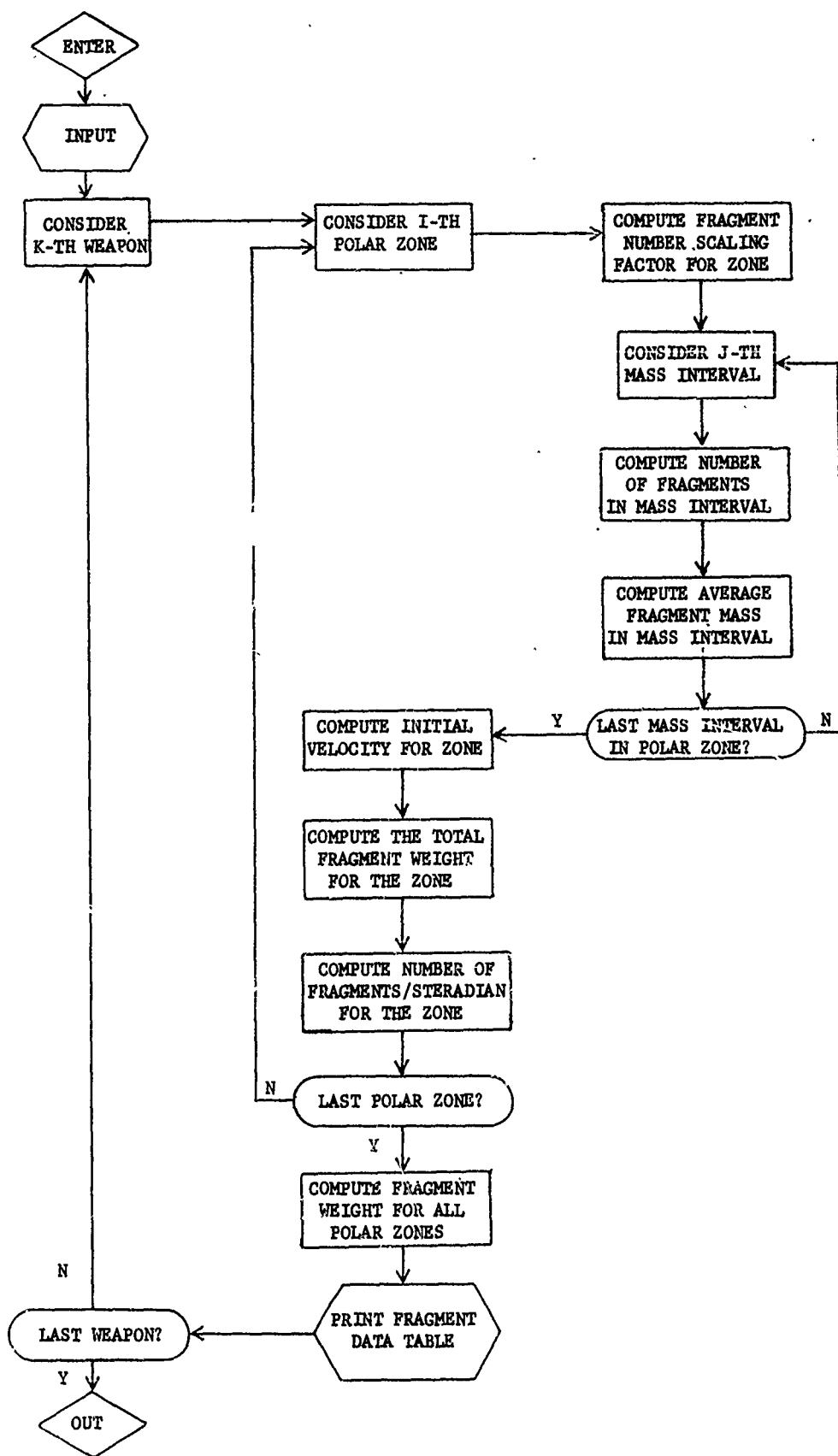


Figure 2. Flow Chart

b. The initial fragment velocity for the polar zone is determined from the equation,

$$V = \bar{V} \left(\frac{e^w - 1}{w} \right)$$

V = initial fragment velocity, feet/second

\bar{V} = average fragment velocity, feet/second

e = base of natural logarithm

and,

$$w = 0.489 \rho_a C_d R \left(\frac{\bar{A}}{M} \right)$$

for,

ρ_a = air density, pounds/feet³

C_d = drag coefficient

R = radius of velocity arena, feet

$\left(\frac{\bar{A}}{M} \right)$ = area mass ratio, centimeters²/grams.

The value of the area mass ratio is given by the relationship,

$$\left(\frac{\bar{A}}{M} \right) = b(m)^{-c}$$

where,

b = fragment area mass constant

c = fragment area mass exponent

m = fragment mass, which in this case is the average fragment mass taken over the entire polar zone.

c. The total fragment weight per polar zone is obtained by merely summing the product of the number of fragments and the average fragment weight for each mass interval over the total polar zone.

d. The steradian measure of the polar zone is,

$$A_k = 2\pi(\cos \theta_{k+1} - \cos \theta_k)$$

where θ_k is as defined in subparagraph a, above. Dividing the total number of fragments in the polar zone by A_k yields the number of fragments per steradian for the zone.

The remainder of the pertinent fragmentation data--heaviest fragment recovered and the number of hits (fragment impacts on velocity arena wall) from which the average velocity is calculated--is obtained by observing the raw test data. These values are inserted manually in the spaces provided in the output format. The total process is then repeated for each successive polar zone until the total fragment space has been spanned.

A listing of the program deck, the input format, and a sample of the input and output from the program are included in Appendix A.

APPENDIX A

PROGRAM DECK

A listing of the FORTRAN IV program deck designed for execution on the IBM 7030 is given as Figure A-1.

INPUT FORMAT

A description of the input format is shown in Figure A-2, and the various input data required by the program identified below:

<u>Card Type 1</u>	NRUNS	Number of fragment data tables to be prepared
<u>Card Type 2</u>	INT	Number of mass intervals per polar zone (≤ 20)
	NZONE	Total number of polar zones (≤ 36)
	MULT	MULT = $36/\text{NZONES}$ (Integer)
<u>Card Type 3</u>	TAB	Table number
	WEAP	Weapon identification (center in these columns)
<u>Card Type 4</u>	EXPLO	Type of explosive
	REFNO	Reference number
	NR	Number of rounds tested
	RADM	Radius of mass arena
	R	Radius of velocity arena
	H	Height of arena
<u>Card Type 5</u>	RHOA	Air density
	CD	Drag coefficient
	B	Fragment area/mass constant
	C	Fragment area/mass exponent
<u>Card Type 6</u>	NFRAG	Number of fragments per mass interval per zone

Starting with the first polar zone, list the number of fragments in the largest mass interval, the next largest mass interval, etc., until all mass intervals have been accounted for. Continue listing in the same order for each successive polar zone until all polar zones have been considered.

```

PROGRAM TO EDIT FRAGMENTATION DATA
  DIMENSION NFRAG(20,36),W(20,36),VBAR(36),THETA(37),AK(37),CAK(37)
  1,CNBAR(20,36),CMBAR(20,36),NO(36),VC(36),AINT(20),RAD(37),
  2WEAP(10),EXPLO(5),FRAG(20,36),REFNO(2),ASIN(37),WBAR(36)
  EQUIVALENCE (NFRAG,FRAG)
10  FORMAT(11A5)
11  FORMAT(7A5,I5,3F5.1)
12  FORMAT(4F10.5)
13  FORMAT(14I5)
14  FORMAT( 7F10.5)
20  FORMAT( 1H1,44X,6HTABLE ,A5,18HFRAGMENTATION DATA/37X,10A5)
21  FORMAT(11H1AVERAGE OF,I5,/H ROUNDS/22H RADIUS OF MASS ARENA ,F5.1,
  14H FT./26H RADIUS OF VELOCITY ARENA ,F5.1,4H FT./19H HEIGHT OF CEL
  20TEX ,F4.1,4H FT./16H TYPE EXPLOSIVE ,5A5/15H REFERENCE NO. ,2A5)
22  FORMAT(126HK
  1 - - - - - FRAGMENT WEIGHT GROUPS (GRAMS) - - - - -
  2 - - )
23  FORMAT(13H POLAR , F5.1,2H +,3X,6(4XF6.3,1H-,F6.3))
24  FORMAT(123H ZONE
  1 N M N M N M N M
  2 M)
25  FORMAT( 1H ,I3,1H-,I3,2(1XF7.3),6(2XF7.3,1XF7.3))
26  FORMAT(52HON=AVERAGE NUMBER OF FRAGMENTS PER TOTAL POLAR ZONE./
  133H M=AVERAGE FRAGMENT MASS (GRAMS)./46H V=DISTANCE OF FRAGMENT FL
  2IGHT/TIME OF FLIGHT.)
27  FORMAT(1H5,/)
28  FORMAT(50HL- - - - - ,38X,
  122HTOTAL NO. OF FRAG.)
29  FORMAT( 2H ,2(F6.3,1H-,F6.3,4X),F6.3,1H-,F6.3,56H HEAVIEST V
  1ELOCITY (FT/SEC) FRAGMENT PER/108H N M
  2N M N M FRAGMENT HITS AVERAGE INITIAL WE
  3IGHT (GMS) STERADIAN)
30  FORMAT (1H ,F7.3,1X,F7.3,2(2X,F7.3,1X,F7.3), 16X,2(1XF7.2),
  13XF9.2,7X15)
31  FORMAT(1H ,84XF9.2)
  READ 13,NRUNS
  THETA(1)=0.0
  RAD(1)=0.0
  ASIN(1)=0.0
  DO 400 LL=1,NRUNS
  READ 13,INT,NZONE,IMULT
  READ 10,TAB,WEAP
  READ 11,EXPLO,REFNO,NR,RADM,R,H
  READ 12,RHOA,CD,B,C
  READ 13, ((NFRAG(I,J),I=1,INT),J=1,NZONE)
  READ 14, ((W(I,J),I=1,INT),J=1,NZONE)
  READ 14,(VBAR(J),J=1,NZONE)
  READ 14,(AINT(I),I=1,INT)
  AMULT=IMULT
  SX=H/SQRT(H*H+4.*RADM*RADM)
  CX=SQRT(1.-SX*SX)
  X=ATNG(SX,CX)
  XD=X*57.2957795131
  NZ=NZONE+1
  DO 100 M=2,NZ
  THETA(M)=THETA(M-1)+5.0*AMULT
  RAD(M)=THETA(M)*.01745329251994

```

Figure A-1. Program Deck Listing.

```

PRINT 26
PRINT 27
PRINT 28
PRINT 29, (AINT(I-1),AINT(I),I=8,INT)
DO 302 J=1,NZONE
302 PRINT 30, (CNBAR(I,J),CMBAR(I,J),I=8,INT),VBAR(J),VO(J),WBAR(J),
INO(J)
PRINT 31,WSUM
400 CONTINUE
RETURN
END

```

Figure A-1 (Cont'd)

```

PRO=.489*RHOA*CD*R
ANR=NR
WSUM=0.0
IST=0
DO 300 J=1,NZONE
JJ=J+1
DIV=SX/SIN(RAD(JJ))
DIV1=SQRT(1.-DIV*DIV)
ASIN(JJ)=ATNQ(DIV,DIV1)
IF(SX.GE.SIN(RAD(JJ)).AND.SX.GE.SIN(RAD(J))) GO TO 140
IF(SX.LE.SIN(RAD(JJ)).AND.SX.LE.SIN(RAD(J))) GO TO 130
IF(IST.EQ.1) GO TO 131
AK(J)=THETA(JJ)-THETA(J)
DEGX=ABS(XD-THETA(J))
CAK(J)=2.0*DEGX + (6.28318531*ABS(COS(RAD(JJ))-CX)
1*(THETA(JJ)-XD))/((RAD(JJ)-X)*(SIN(RAD(JJ))*ASIN(JJ)+SX*1.5707963)
2)
IST=1
SAVE=AK(J)
SAVEC=CAK(J)
GO TO 142
131 AK(J)=SAVE
CAK(J)=SAVEC
GO TO 142
140 AK(J)=(COS(RAD ( J ))-COS(RAD(JJ)))*3.14159265
GO TO 141
130 AK(J)=(SIN(RAD (JJ))*ASIN(JJ)+SIN(RAD (J))*ASIN(J))*(RAD (JJ)-RAD
1(J))
141 CAK(J)=6.28318531*(COS(RAD ( J ))-COS(RAD(JJ)))
142 CB=CAK(J)/AK(J)
CAK(J)=6.28318531*(COS(RAD ( J ))-COS(RAD(JJ)))
150 U=0.0
WBAR(J)=0.0
SNBAR=0.0
SMB=0.0
DO 200 I=1,INT
CNBAR(I,J)=CB*(FRAG(I,J)/ANR)
CMBAR(I,J)=W(I,J)/ FRAG(I,J)
WBAR(J)=CNBAR(I,J)*CMBAR(I,J)+WBAR(J)
IF(CMBAR(I,J)) 221,221,210
210 U=U+1.0
SMB=CMBAR(I,J)+SMB
221 IF(CNBAR(I,J)) 200,220,220
220 SNBAR=CNBAR(I,J)+SNBAR
200 CONTINUE
SMBAR=(1./U)*SMB
ABAR=B*(SMBAR**(-C))
OMEGA=PRO*ABAR
VO(J)=VBAR(J)*((2.71821828459**OMEGA-1.)/OMEGA)
NO(J)= SNBAR/CAK(J)
WSUM=WSUM+WBAR(J)
300 CONTINUE
PRINT 20,TAB,WEAP
PRINT 21,NR,RADM,R,H,EXPLO,REFNO
PRINT 22
PRINT 23,AINT(1),(AINT(1),AINT(1+1),I=1,6)
PRINT 24
DO 301 J=1,NZONE
301 PRINT 25, THETA(J),THETA(J+1),(CNBAR(I,J),CMBAR(I,J),I=1,7)

```

Figure A-1 (Cont'd)

Card Type 7

W

Total weight of fragments
per mass interval per zone

Starting with the first polar zone, list the total weight of the recovered fragments in the largest mass interval, the next largest mass interval, etc., until all mass intervals have been accounted for. Continue listing in the same order for each successive polar zone until all polar zones have been considered.

Card Type 8

VBAR

Average fragment velocity
per zone

Starting with the first polar zone, list the average fragment velocity, and continue listing for each successive polar zone until all have been considered.

Card Type 9

AINI

Mass interval

Starting with the largest mass interval, list the value of the lower bound, and continue listing until all mass intervals have been considered. Since all polar zones have the same mass intervals, they are listed only once.

INPUT AND OUTPUT

A sample of the input and output from the program is presented in Figures A-3 and A-4. This table is based on data from static detonation tests of four 8'/55 Mk 25 Mod 1 (HC) projectile warheads.

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CARD TYPE 1

[illegible]

STUDY

CARD TYPE 2.

[illegible]

**THE
BOOK
TITLE**

CARD TYPE 3

[illegible]

TAB

APPENDIX

Figure A-2. Input Format.

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CARD TYPE 4

CARD TYPE 5

VOIR

0
2
6

22

CARD TYPE 6

Figure A-2 (Cont'd.)

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[illegible][illegible][illegible]

Figure A-2 (Cont'd.)

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1	10	36	1	3/70	PROJECTILE MARK 34 MOD 2 (HEI)	20-33	4	20.0	20.0	8.0	B31	1
23	COMP A-3	0.07650	0.62	0.55	0.13333							2
				5	2	59	1	2	13			3
	9	63								1		4
			2			1	1	42		5	16	5
			3	29				1				6A
	2			1	1	13	2	1	25			6B
	1	13	1				1			12	1	6C
	1	1	1	2	3		2	17		1		6D
	3	2	2	10	1				4	2	1	6E
	2			1	4	1	3	2	1	9	1	6F
		1	3		7	9	2	1	1	1	1	6G
	8	12					2		3	2	9	6H
	1	6	8	14	19	12	27	52	6	1	2	6I
	8	9	10	15	2	5	6		1	4	8	6J
	2		1	3	5	1	5	1	4	14		6K
				1	1	5						6L
	1	13			1	2	4	43	1	2	2	6M
		1		37			1		2	45		6N
			1		55		1					6O
	4	45			1	2	1	1	3	55		6P
	1	1		2	3		4	42	3	2	3	6Q
	4	2	11	73	5		1	5	4	4	17	6R
	4		2	1	3	2	5	2	7	41		6S
			.9		.4							6T
							4.0	.7	1.7	42.5		6U
							3.9			2.4		6V
	3.2		1.6				2.4	1.0				6W
					6.7				1.0	.5		6X
	1.7				1.4		1.6					6Y
	5.2							1.8	1.3	.5		6Z
38.3										1.1		7A
		.3		.6								7B
		2.3				.7		.4	.7	66.8		7C
								2.4		.7		7D
	.6	.4		40.4				.81	38.3	3.1		7E
				.7								7F
7.8		6.6		4.2		4.6		3.6		.6		7G
.8								5.4		9.4		7H
4.7		1.7		.6		.6		34.7				7I
		17.1		4.6		1.7		.7	1.0	.5		7J
52.1						5.6		16.2	2.7	2.8		7K
1.5		.4		.9		13.3		20.2	7.8	11.3		7L
		2.6		4.4				2.3	.9	25.9		7M
9.9				5.1		3.3		2.9	6.2	2.2		7N
3.0		1.5								7.6		7O
		4.5		1.6		3.9		2.5	118.2			7P
												7Q
												7R
												7S
												7T
												7U
												7V
												7W
												7X
												7Y
												7Z

Figure A-3. Sample Input.

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7.9	34.5	31.2	34.2	27.7	9.6	11.2	A7A
5.0	96.0	9.8	15.5	17.0	29.5	4.2	B7B
11.8	7.2	4.0	.8	25.6	50.6	48.2	C7C
	4.2	9.6	12.0	3.7	2.1	1.74	D7D
28.7		8.6	16.9	18.7	2.2	8.5	E7E
.9	1.4	1.1					F7F
			.8	.3	.4		G7G
							H7H
.4	.5						I7I
	1.8	1.8	1.1	.9			J7J
				1.8	1.6	1.5	K7K
1.0			.8				L7L
	.9						M7M
					1.0	1.5	N7N
						1.5	O7O
		.7					P7P
			.7		.8		Q7Q
						.7	R7R
1.9	1.0			7.5	13.1	4.2	S7S
2.2			1.2	1.4		10.3	T7T
8.2	6.2		4.8	3.9		1.5	U7U
1.1	54.3	20.0	23.9	11.0	7.1	7.1	V7V
5.3	1.7	4.6	2.9	84.8			W7W
6.2	20.3	10.0	4.8	3.1	7.1	2.5	X7X
156.4		14.4	6.0	12.6	4.2	7.6	Y7Y
1.7	2.5	1.8					Z7Z
							8A
							8B
2937.1	3650.7	4111.4	4192.5	4227.5	4099.2	3278.2	8C
2830.0							8D
					1900.0	2043.3	8E
2510.0							8F
11.0	9.0	7.0	5.0	3.0	2.0	1.0	9A
.625	.25	.0					9B

Figure A-3 (Cont'd)

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TABLE 23 FRAGMENTATION DATA
3/70 PROJECTILE MARK 34 M8D 2 (HEI)

Figure A-4. Sample Output.

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AVERAGE OF 4 ROUNDS
RADIUS OF MASS ARENA 20.0 FT.
RADIUS OF VELOCITY ARENA 20.0 FT.
HEIGHT OF CELOTEX 8.0 FT.
TYPE EXPLOSIVE COMP A-3
REFERENCE NO. 20-33

POLAR ZONE	11.0 +		11.000- 9.000		9.000- 7.000		7.000- 5.000		5.000- 3.000		3.000- 2.000		2.000- 1.000	
	N	M	N	M	N	M	N	M	N	M	N	M	N	M
0- 5	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
5- 10	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
10- 15	0.628	42.500	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.628	3.900	-0.000	-0.000	-0.000	-0.000
15- 20	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
20- 25	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.911	3.350	-0.000	-0.000	-0.000	-0.000
25- 30	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
30- 35	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.100	5.200	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
35- 40	4.786	19.150	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.393	1.100
40- 45	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.665	2.300	-0.000	-0.000
45- 50	5.832	33.400	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.916	2.400	-0.000	-0.000
50- 55	3.143	40.400	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.143	3.100	-0.000	-0.000	-0.000	-0.000
55- 60	3.345	38.300	-0.000	-0.000	3.345	7.800	3.345	6.600	3.345	4.200	6.691	2.300	10.036	1.200
60- 65	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.522	5.400	-0.000	-0.000	14.087	2.350	10.565	1.567
65- 70	3.671	34.700	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	14.682	4.275	7.341	2.300	3.671	1.700
70- 75	7.582	26.050	-0.000	-0.000	-0.000	-0.000	3.791	5.600	15.164	4.050	3.791	2.700	11.373	1.267
75- 80	3.882	13.300	-0.000	-0.000	3.882	7.800	7.764	5.650	-0.000	-0.000	3.882	2.600	11.646	1.467
80- 85	7.886	12.950	-0.000	-0.000	-0.000	-0.000	3.943	5.100	3.943	3.300	3.943	2.900	15.772	1.550
85- 90	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	7.947	3.800	-0.000	-0.000	11.921	1.500
90- 95	27.816	16.886	-0.000	-0.000	3.974	7.900	23.842	5.750	31.789	3.900	55.631	2.443	75.499	1.458
95-100	23.658	16.000	3.943	9.800	7.884	7.750	11.829	5.667	27.601	4.214	7.884	2.100	31.544	1.475
100-105	7.764	12.800	19.410	10.120	8.033	8.600	-0.000	-0.000	3.882	4.200	15.528	2.400	31.056	1.500
105-110	7.582	14.350	-0.000	-0.000	23.292	8.600	11.373	5.633	18.954	3.740	3.791	2.200	18.954	1.700
110-115	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
115-120	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
120-125	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
125-130	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.345	1.800
130-135	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3.143	1.800
135-140	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
140-145	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
145-150	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	2.393	1.500
150-155	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
155-160	-0.000	-0.000	-0.000	-0.000	1.456	7.500	2.911	6.550	1.456	4.200	-0.000	2.200	-0.000	-0.000
160-165	-0.000	-0.000	1.095	10.300	1.095	8.200	1.095	6.200	-0.000	-0.000	2.189	2.400	3.284	1.300
165-170	1.884	18.100	1.256	10.000	1.884	7.967	1.256	5.500	1.256	3.550	1.884	2.367	2.513	1.325
170-175	2.500	16.960	-0.000	-0.000	-0.000	-0.000	0.500	6.200	2.500	4.060	2.000	2.500	2.000	1.200
175-180	2.000	39.100	-0.000	-0.000	1.000	7.250	0.500	6.000	1.500	4.200	1.000	2.450	2.500	1.520

N=AVERAGE NUMBER OF FRAGMENTS PER TOTAL POLAR ZONE.
M=AVERAGE FRAGMENT MASS (GRAMS).
V=DISTANCE OF FRAGMENT FLIGHT/TIME OF FLIGHT.

Figure A-4 (Cont'd)

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1.000- 0.625		0.625- 0.250		0.250- 0.000		HEAVIEST FRAGMENT	VELOCITY (FT/SEC) HITS AVERAGE INITIAL	TOTAL FRAGMENT WEIGHT (LBS)	NO. OF FRAG. PER STERADIAN
N	M	N	M	N	M				
-0.00	-0.00	1.000	0.450	6.500	0.031		-0.00	0.65	313
2.500	0.800	1.000	0.350	29.500	0.029		-0.00	3.20	461
1.884	0.800	5.653	0.356	39.573	0.025		-0.00	33.67	407
-0.00	-0.00	5.473	0.480	17.513	0.063		-0.00	3.72	139
1.456	1.000	1.456	0.500	61.141	0.040		-0.00	14.41	319
-0.00	-0.00	5.365	0.467	51.860	0.055		-0.00	5.36	226
4.201	0.900	6.301	0.433	48.311	0.022		-0.00	18.48	206
-0.00	-0.00	2.393	0.300	59.829	0.024		-0.00	96.44	207
2.665	0.700	2.665	0.400	34.650	0.054		-0.00	10.93	115
2.916	0.700	2.916	0.600	37.907	0.031		-0.00	206.74	129
3.143	0.700	-0.00	-0.00	37.717	0.067		-0.00	141.47	108
-0.00	-0.00	6.691	0.300	56.873	0.047		-0.00	222.47	202
7.043	0.850	7.043	0.300	35.217	0.060		-0.00	78.89	159
3.671	0.700	11.012	0.333	25.694	0.071		-0.00	221.33	137
7.582	0.750	3.791	0.400	34.118	0.100		2937.10	315.40	166
-0.00	-0.00	27.174	0.329	34.937	0.100		3650.70	243.79	188
11.829	0.733	31.544	0.375	47.316	0.125		4111.40	236.58	239
7.947	0.800	35.763	0.433	91.394	0.109		4192.50	79.87	282
47.684	0.800	107.289	0.415	206.630	0.096		4227.50	1110.64	1059
35.487	0.800	39.430	0.400	59.145	0.053		4099.20	772.04	457
11.646	1.233	19.410	0.420	108.694	0.062		3278.20	612.34	449
3.791	0.900	15.164	0.450	53.072	0.079		2830.00	329.81	261
3.671	0.800	3.671	0.300	18.353	0.080		-0.00	5.51	50
-0.00	-0.00	3.522	0.400	45.782	0.038		-0.00	3.17	101
6.691	0.900	6.691	0.550	86.982	0.035		-0.00	18.73	224
6.286	0.800	12.572	0.375	135.152	0.023		-0.00	18.54	361
2.916	0.900	-0.00	-0.00	107.888	0.022		-0.00	4.96	274
-0.00	-0.00	7.996	0.333	157.260	0.025		-0.00	6.66	446
-0.00	-0.00	4.786	-0.00	107.692	0.016		-0.00	5.26	344
2.100	0.700	-0.00	-0.00	115.526	0.015		-0.00	3.15	399
1.788	0.700	7.153	0.4.5	80.472	0.022		-0.00	6.44	353
-0.00	-0.00	4.367	0.400	80.066	0.025		-0.00	43.09	437
-0.00	-0.00	4.378	0.375	45.972	0.026		-0.00	39.40	358
1.256	0.850	6.910	0.418	45.854	0.040		1900.00	86.62	555
2.000	0.775	8.500	0.418	23.000	0.054		2043.30	69.40	601
1.000	0.850	3.500	0.357	20.500	0.044		2510.00	103.95	1401
								5173.13	

Figure A-4 (Cont'd)

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